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16. Abstract
The development of a system for thermal destratification of large reservoirs is presented. Rate of change of the water volume affected and the magnitude of aeration were determined in the central pool of Eufaula Reservoir in eastern Oklahoma. The pilot system was undersized for circulating the entire volume of the central pool, yet 65,000 acre-feet of water below a depth of 22 feet was aerated by the 25th day of operation. Aeration effects extended as far as 2.5 miles from the point where the system was installed, covering an area of approximately 3,000 acres at a depth of 22 feet. Rate of change of hydrodynamic aeration trajectories and thermal effect versus mechanical energy input are discussed. Pilot system design and operational limitations served as a guide for design of a more effective system for continued research and development of destratification of large reservoirs. Interesting changes in vertical distribution and concentrations of fish have prompted proposals from other agencies to conduct parallel research on effects of destratification on fish populations and other biological parameters. (Woodard-USGS)

17a. Descriptors
*Reservoirs, *Thermal stratification, *Aeration, *Heat transfer, *Water quality control, Oxygenation, Oklahoma, Ecology, Cooling, Diffusion, Water circulation, Mass transfer, Thermodynamic behavior, Methodology, Water pollution control,

17b. Identifiers
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17c. COWRR Field & Group 05G, 02H, 05B

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Abstractor T.H.Woodard 10 Jan 72 Institution U.S.Geol.Survey,Water Res. Div.

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PILOT STUDY

OF

DYNAMICS OF RESERVOIR DESTRATIFICATION

by

Lowell E. Leach,
William R. Duffer,
and
Curtis C. Harlin, Jr.

Water Quality Control Research Program
Robert S. Kerr Water Research Center
Ada, Oklahoma

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration

PILOT STUDY

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INTRODUCTION

There is immediate national interest in the broad, new field of reservoir water quality research directed toward more beneficial reservoir operations and management practices. Many people will be affected directly or indirectly by the future control of impounded water supplies and their management. The goal of these practices should be the ultimate control of water quality to insure that the entire volume of water impounded is available for maximum beneficial use at all times.

In recent years, the stagnation of water at lower depths in impoundments, due to the natural processes of thermal stratification, has become a prime concern and a cause of concentrated effort for remedial measures. Stratification greatly reduces the potential beneficial uses of the lower levels in impoundments for municipal and industrial purposes and causes detrimental downstream effects below impoundments during summer power releases. Dissolved oxygen levels decrease in the lower density layers due to stratification.

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Fish habitat and production of fish-food organisms are limited in the oxygen-depleted layers at a critical time when most of their annual growth occurs.

Many recent papers describe the effects of artificial destratification devices used to aerate thermally stratified impoundments. The primary effort directed toward control of thermal stratification has been artificial destratification using various types and arrangements of mixed-flow pumps (1) or compressed air systems (2-6) to mix the hypolimnion and epilimnion water. The compressed air system is believed to be the most efficient and was used for this study. The present research is unique because the destratification system was established and evaluated in the central pool of an extremely large reservoir. Other researchers have been very effective in destratification of relatively small impoundments where the aeration system utilizes the confinement of the banks to restrict the limits of the system causing faster and more homogenous aeration. However, for more general use, the system must be developed for effective application in large reservoirs.

The ultimate goal of destratification research at the Robert S. Kerr Water Research Center is to develop design criteria to the extent that the most economical size and arrangement of systems can be designed for reservoirs of different characteristics. The approach being used is to design systems for application in selected reservoirs. In each case, the system will be evaluated and design modifications made to the particular reservoir characteristics. The primary objective

of this project is to develop the technique of destratifying large reservoirs utilizing one or more air diffusor systems strategically located to give the most desirable cost-benefit ratio.

The pilot study here reported was conducted to gain knowledge of kinetics and hydrodynamic effects of an air diffusor system placed near the bottom of a reservoir. The rate of change of the thermocline resulting from aeration and the trajectory and limits of the aeration effects, as well as the degree and rate of change of effects, were primary considerations in evaluating the dynamics of the aeration system. Evaluation of a compressor with particular capabilities and its subsurface air diffusor system, based on its input and resulting net effects, supplies a base from which a more applicable and efficient system can be designed.

This report presents the progress and development of the pilot study of the dynamics of destratification of a large reservoir by utilizing a compressed air diffusor system. The pilot study research was conducted by personnel of the Water Quality Control Research Program, Robert S. Kerr Water Research Center, during the summer and early fall of 1967 at Eufuala Reservoir, a U. S. Army Corps of Engineers reservoir located in eastern Oklahoma.

THERMAL STRATIFICATION EFFECTS

Reservoirs in the Southwestern United States generally become density-stratified during mid-May and remain so until mid-October, the most pronounced stratification occurring from June until mid-September. The fundamental causes of the development of stratification are discussed in detail in most works on limnology (7-9).

Normally, at the end of the winter season, water in a reservoir is cold and has a relatively high density. As the atmospheric temperature increases, the temperature of both the surface and inflowing waters increases with a corresponding decrease in density. The difference in density between the top and bottom strata of water eventually becomes great enough to prevent wind-induced mixing of the water mass, and stratification occurs.

Between the warm, relatively light surface stratum (epilimnion) and the colder and denser bottom stratum (hypolimnion), there is a third stratum (metalimnion or thermocline) where the temperature gradient declines rapidly with depth. The metalimnion remains in place throughout the period of summer stratification and acts as a flexible diaphragm preventing mixing of the epilimnion and hypolimnion.

In the southern portion of the United States, the temperature of the epilimnion may rise to 30°C or even higher. Wind-induced mixing usually maintains a rather uniform temperature throughout the depth of the epilimnion.

A small amount of radiant energy from the sun penetrates to the bottom of the reservoir and produces a small temperature gradient from top to bottom in the hypolimnion (10). The hypolimnion often consists of water that was stored during winter or spring. Since stratification prevents the warm atmosphere from reaching the hypolimnion, warming is slight. Even in southern areas, the summer temperature of the hypolimnion may remain as low as 7 to 10°C.

In the typical large storage reservoirs, the epilimnion is generally about 25 to 40 feet deep; the metalimnion is 10 to 20 feet thick; and the hypolimnion occupies the remainder of the depth to the bottom (10).

The epilimnion is circulated by wind-induced currents during periods of stratification and becomes aerated to the point where the dissolved oxygen is near saturation.

The hypolimnion, however, is completely shut off from the atmosphere; and sunlight usually does not penetrate deeply enough to support photosynthesis. Dissolved oxygen is removed from the water by organic decomposition and cannot be replaced. Detention of water for several months in the hypolimnion often permits total dissolved oxygen depletion--even in reservoirs receiving inflows nearly saturated with dissolved oxygen. Stagnant water of the hypolimnion requires extensive treatment at very high cost before it can be used for human consumption or certain industrial purposes. Stratification, therefore, imposes restrictions on water use from a storage reservoir.

New reservoirs that are allowed to fill without having the vegetation cleared in the impoundment area may have a layer of stagnant water above municipal water supply intake lines, thus, seriously deteriorating the water supply.

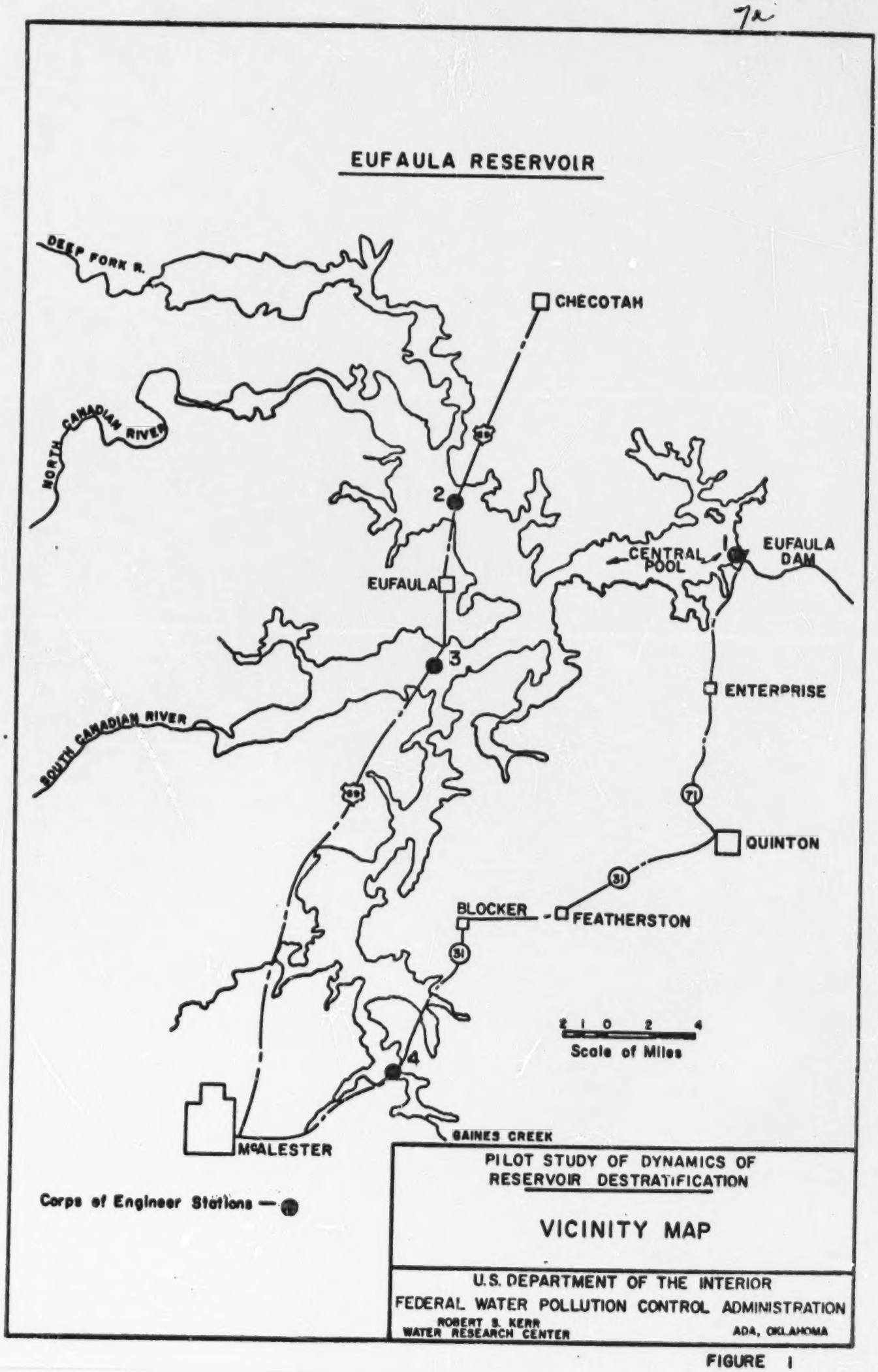
At hydroelectric dams, the penstocks normally are located fairly deep in the reservoir; water passing through the turbine penstocks comes from the hypolimnion which may contain high concentrations of hydrogen sulfide and almost no dissolved oxygen. The discharge has very little energy left as it leaves the tailrace and therefore is not reaerated properly. This discharge water is often detrimental to fish and causes serious problems in downstream water uses.

Many changes occur as a result of reservoir stratification such as the reduction of iron and manganese compounds. Sufficient research has not been conducted on many of these parameters to fully understand or evaluate their influence on water quality and the biota. Some of the conditions which exist as a result of stratification appear to be detrimental to fish within the reservoir and to be responsible for the accumulation of toxic substances in the hypolimnion.

RESERVOIR BACKGROUND STUDY

Eufaula Reservoir was selected as the pilot study area for two significant reasons. The first of these was the physical characteristics of the body of water. There are several interconnected bodies of water within the reservoir (Figure 1). The reservoir has a surface area of 102,500 acres and a storage of approximately 2,800,000 acre-feet at 585 feet, which is the maximum power pool elevation. The central pool, having a surface area of 10,800 acres and a volume of approximately 570,000 acre-feet at maximum power pool elevation, is more than ten times as large as any reservoir in which destratification has been reported. The separate, almost isolated, upstream bodies of water at the reservoir are outside the influence of direct destratification effects in the central pool and serve as a control to illustrate reservoir changes due to normal seasonal conditions.

The second reason for selecting Eufuala Reservoir as the pilot study site was the availability of historical water quality data from several monitoring stations within the reservoir. Eufaula Reservoir is one of several in the United States presently being monitored by the U. S. Army Corps of Engineers as part of a national program to develop criteria for more efficient water quality conservation practices. The Tulsa District Corps of Engineers has established continuous recording stations as shown in Figure 1 at points 1, 2, 3, and 4. Temperature, dissolved oxygen, and conductivity have been monitored at these stations since August 1966.



PILOT STUDY OF DYNAMICS OF RESERVOIR DESTRATIFICATION

VICINITY MAP

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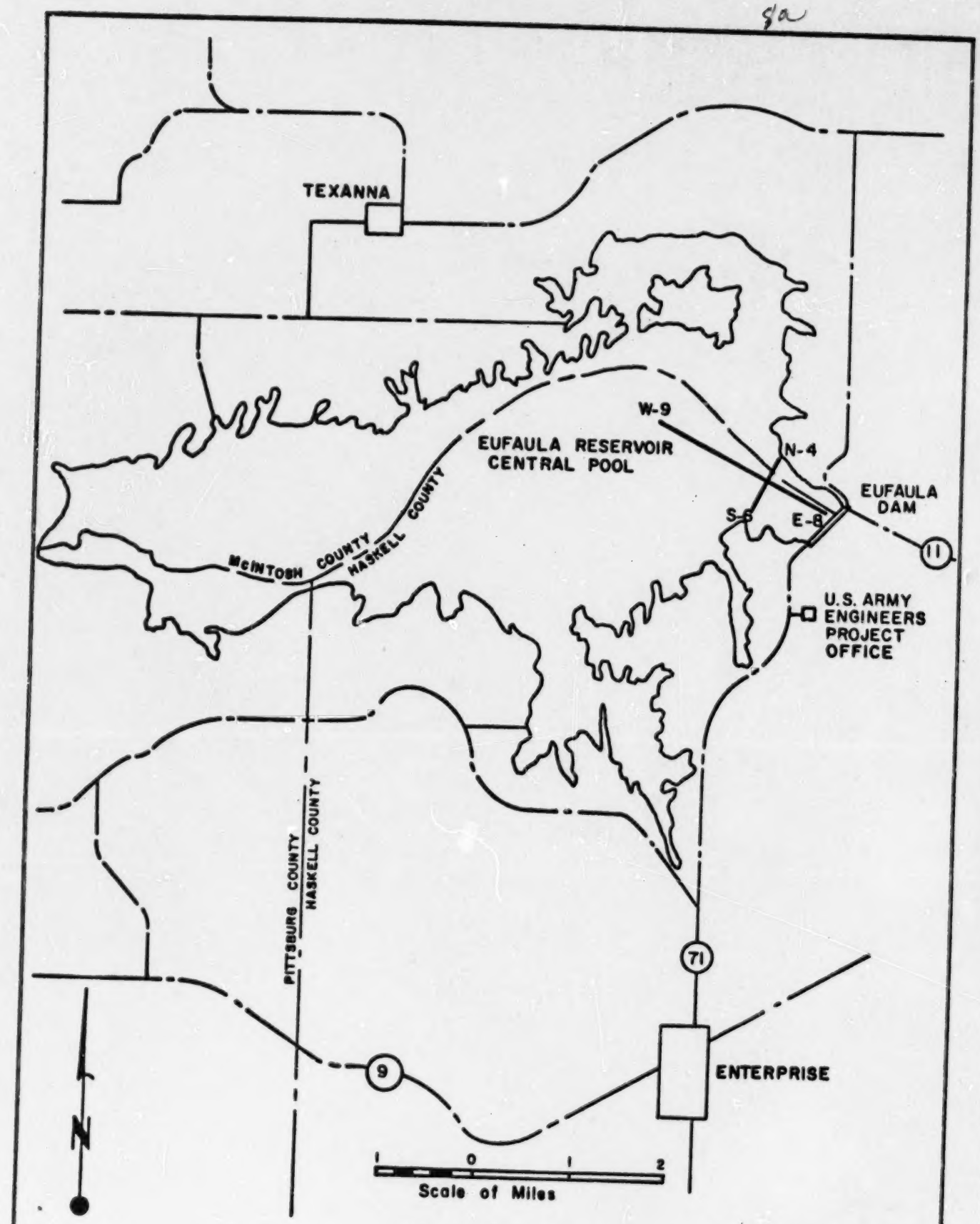
FIGURE 1

A continuous record of these parameters is made at one level and vertical profiles are taken by Corps personnel on a weekly basis at each station. Further, these stations are conveniently located for monitoring in connection with the destratification project, since they provide data to establish differences between separate, almost isolated, bodies of water prior to and during aeration.

In early June, 25 buoy stations were located in the central pool of Eufaula Reservoir (Figure 2). They were arranged in a cross pattern and stationed approximately 500 feet apart, with the center of the cross located about 3,600 feet upstream from the dam. Vertical temperature and dissolved oxygen profiles were measured at these stations at 5-foot intervals from the surface to the bottom. Vertical profiles were measured on four separate occasions prior to artificial destratification for the purpose of determining the thermal stability and level of stratification. The thermocline was found to be approximately 22 feet below the surface, and it remained at that level for each of the four separate measuring periods.

Since there was very little variation among stations, mean conditions of temperature and dissolved oxygen are presented for all measured buoy stations on each of the four separate monitoring dates (Figure 3). Dissolved oxygen levels in the depth from zero to 22 feet ranged from 10 to 6 ppm at the surface, decreasing to about 5 ppm at 22 feet, depending on the weather conditions at the time of monitoring. Dissolved oxygen levels below 22-foot depths rapidly decreased to near zero and generally remained constant for



Radiating Buoy Stations
W-9 Through E-8 and N-4 Through S-6

PILOT STUDY OF DYNAMICS OF
RESERVOIR DESTRATIFICATION

PROJECT LOCATION MAP

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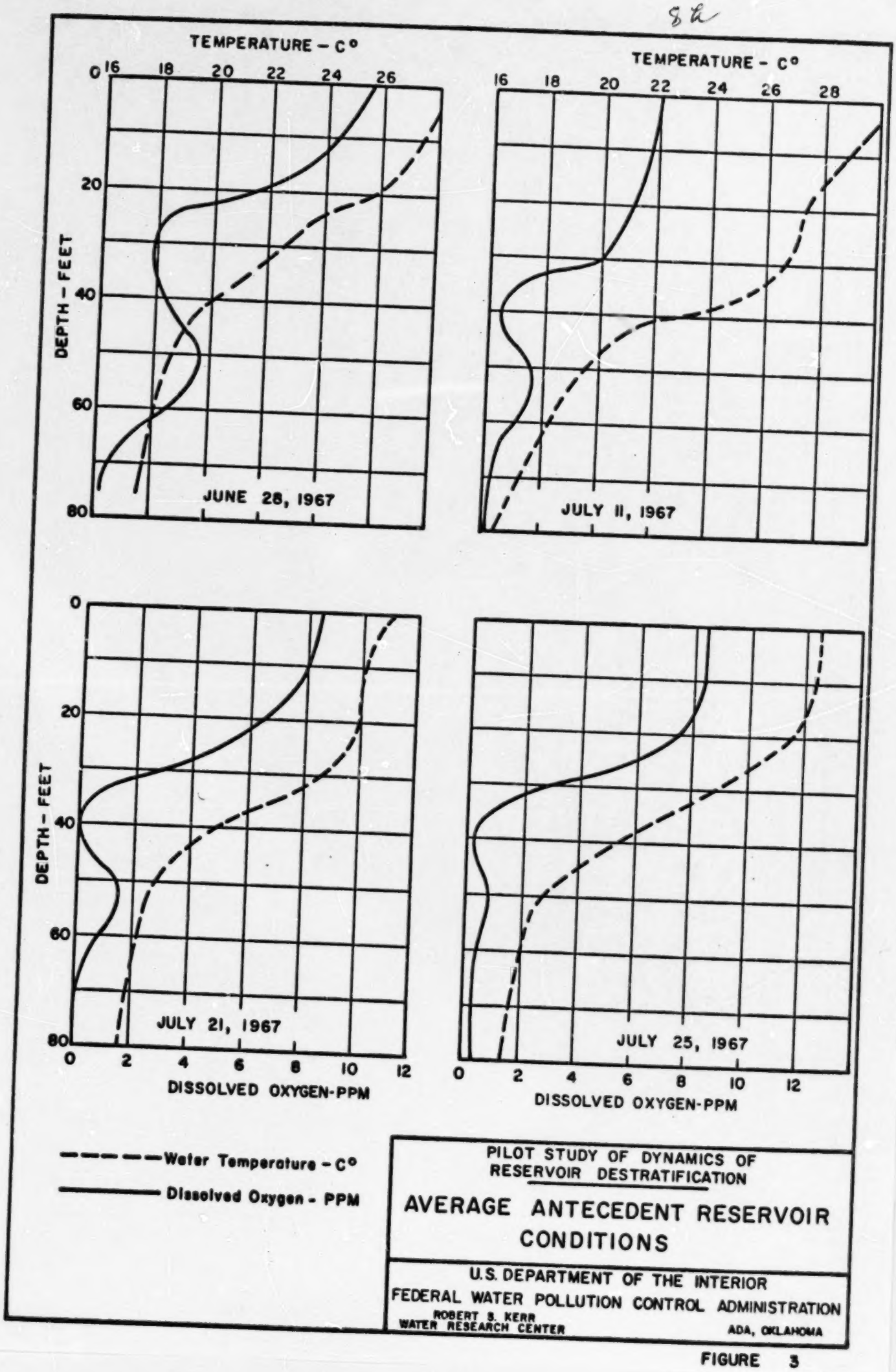
FIGURE 2



PILOT STUDY OF DYNAMICS OF RESERVOIR DESTRATIFICATION

AVERAGE ANTECEDENT RESERVOIR CONDITIONS

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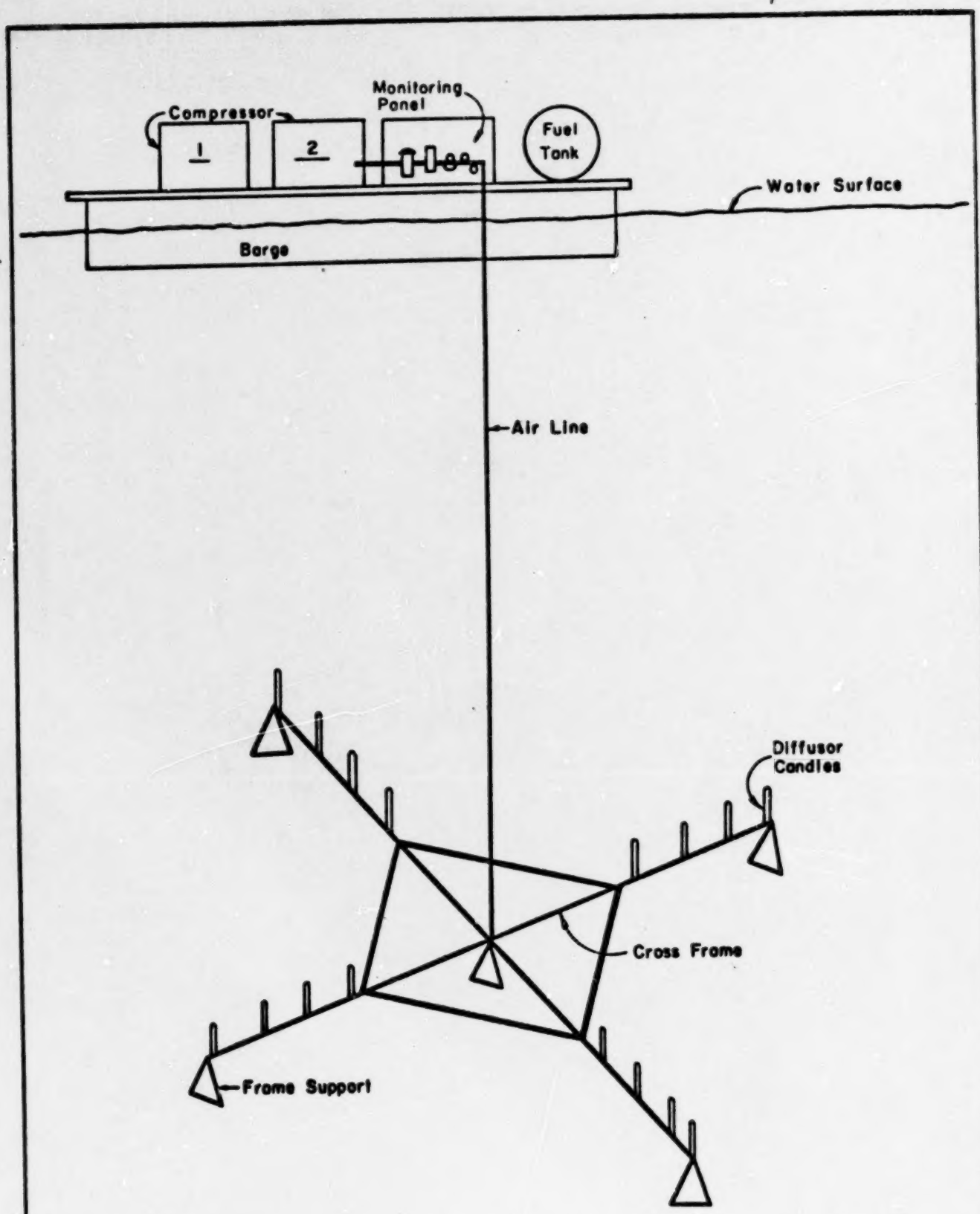
FIGURE 3

the four separate monitoring periods. The higher oxygen concentration at the 50-foot depth gradually diminished during antecedent monitoring and immediately disappeared when destratification operations began. One very interesting feature that appears in the dissolved oxygen profiles for all four antecedent monitoring periods is the decreased concentration of oxygen at about the 30- to 40-foot depth resulting in S-shaped curves. This phenomenon was reported by researchers of the Tennessee Valley Authority (11) as having occurred in reservoirs in the Tennessee River Basin during early summer stratification. The TVA researchers suggested that this phenomenon was caused by a concentration of zooplankton at one level which depleted the oxygen. This phenomenon is discussed in detail by Hutchinson (8).

The destratification system was similar to one used in the 1965-1966 research conducted on Boltz and Falmouth Lakes in northern Kentucky (1-3). The system consisted of two diesel-powered, rotascrew-type air compressors mounted on a barge which was anchored near the center of the radiating buoy-monitoring stations (Figure 4). These machines are rated to deliver 150 cfm free air at 100 psig with the engine speed at 2400 rpm. Compressed air discharged from the machines passed through a monitoring panel where the air was filtered, and volume, pressure, and temperature were gauged. Air discharged from the monitoring panel passed through 150 feet of 1-inch diameter hose to a cross-shaped diffusor system located near the bottom of the reservoir at a depth of 73 feet. The cross



PILOT STUDY OF DYNAMICS OF RESERVOIR DESTRATIFICATION

SKETCH OF AERATION SYSTEM

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FIGURE 4

assembly consisted of four 20-foot legs, each with four microporous porcelain-type diffusor stones which were spaced 3 feet apart along the outermost 9 feet of each leg. Compressed air was carried from the 1-inch diameter main line by a half-inch diameter lateral line to each leg. Each diffusor stone was attached to the half-inch lateral line by quarter-inch diameter hose.

The air diffusor stones were commercially fabricated, microporous porcelain, hollow candles having a length of 8-3/16 inches and an interior diameter of 1-1/2 inches. The bubble-forming microporous capillaries had an average radius of 25×10^{-4} cm resulting in 27 percent porosity for each candle.

The aeration effects were monitored initially by simultaneously measuring vertical profiles of dissolved oxygen and temperature at each radiating line of buoys with crews operating four separate dissolved oxygen meters. Measurements were repeated at 4-hour intervals starting at the aeration system and proceeding outward along each radiating line to a station where no change from the preceding readings could be detected. The frequency of sampling was reduced to four times daily on the second day and two times daily on the third and successive days of the first week. Measurements were made every third day following the first week.

DISCUSSION OF RESULTS

Artificial destratification was initiated July 25, 1967, after it had been determined from antecedent measurements that the reservoir was intensely stratified and had become stabilized. Compressors were run alternately at intervals of three days each for a 25-day period of continuous operation. The volume and pressure of the machines were about 140 cfm and 65 psig, respectively, in initial operation and continually declined for the duration of the project, reaching a minimum of 95 cfm at 45 psig after 25 days of operation.

Monitoring dissolved oxygen profiles and recording their changes from a point of injection of a destratification system is a very effective method of evaluating the radiating effects of aeration. Concentrations of dissolved oxygen increased rapidly during the initial period of aeration together with a gradual warming of the water both in depth and lateral distance from the diffusor system.

For convenience in evaluating aeration effects, changes in the vertical levels of 6.0, 4.0, and 1.0 ppm dissolved oxygen resulting from aeration were monitored at each of the radiating buoy stations.

Effects of aeration were first noticed on the second day of operation when the 4.0-ppm dissolved oxygen level had lowered from 28 feet to a depth of 35 feet at the point of aeration and radiated to a noneffective limit of 1,000 feet from the center of the aeration system. After four days of operation, the 4.0-ppm dissolved oxygen level had moved to a depth of 40 feet at the point of

aeration and varied upward in a radiating cone-shaped trajectory to no measurable effect at a distance of 6,500 feet. The radiating cone effect continued for the duration of the aeration period, with the effects having reached a maximum depth of 50 feet at the point of aeration, and varied upward reaching a noneffective limit (22-foot depth) at a distance of 14,200 feet by the end of the 25th day of operation. The volume of water aerated below the 22-foot depth during the aeration operation was 65,800 acre-feet in an area of approximately 3,000 acres.

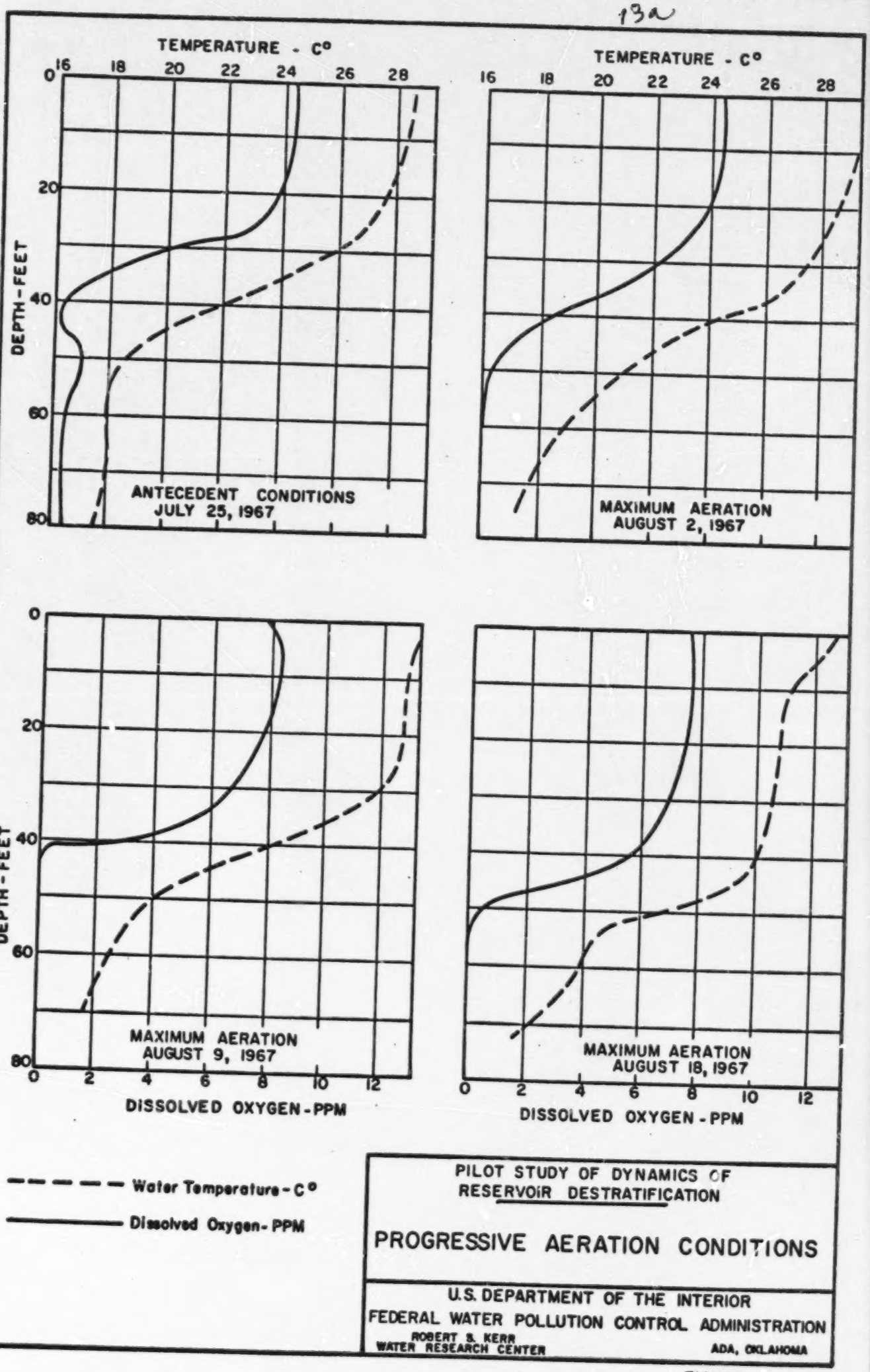
Radiating vertical dissolved oxygen profiles illustrate coning effects much better than temperature profiles for the same stations, since dissolved oxygen changes exhibit much wider ranges than temperature changes.

Data collected during the aeration operation from the U. S. Army Corps of Engineers stations located upstream from the central pool were carefully examined for variations in temperature and dissolved oxygen and compared to antecedent conditions. It was found that these control stations were very stable through the entire period of aeration and did not change from their antecedent conditions. The antecedent conditions in the central pool and the upstream control stations were the same at the beginning of destratification; therefore, comparison of control stations and the stations in the central pool during destratification shows the net effect of destratification.

Profiles in Figure 5 illustrate the gradual lowering of the thermocline and changes in temperature and dissolved oxygen levels in the reservoir at antecedent aeration conditions and at selected periods of aeration. The profile in Figure 5 of antecedent conditions represents a mean for all stations, while the other three profiles represent the maximum effect which occurred at buoy stations near the center of the aerator.

Water temperature in the top 22 feet varied with the wind velocity and air temperature while the dissolved oxygen for that level was stable at approximately 8 ppm. Temperature profiles indicate a gradual warming below the 22-foot depth as destratification progressed, with the most significant increase occurring in the depth range from 22 to 50 feet and only a slight increase below 50 feet. Dissolved oxygen levels below the 22-foot depth show very significant increases down to the 50-foot depth--the effect gradually lowering as destratification progressed.

Progressive changes in a selected dissolved oxygen level illustrate aeration effects (Figure 6). The profile representing the period prior to the destratification operation shows the depth and stable conditions of 4.0-ppm dissolved oxygen level. Profiles representing succeeding periods illustrate progressive lowering of the 4.0-ppm level of dissolved oxygen as a result of continuous aeration. Station zero indicates the point of aeration. The coning effect of the dissolved oxygen levels, previously discussed, is particularly evident in these sections.



PILOT STUDY OF DYNAMICS OF RESERVOIR DESTRATIFICATION

PROGRESSIVE AERATION CONDITIONS

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FIGURE 5

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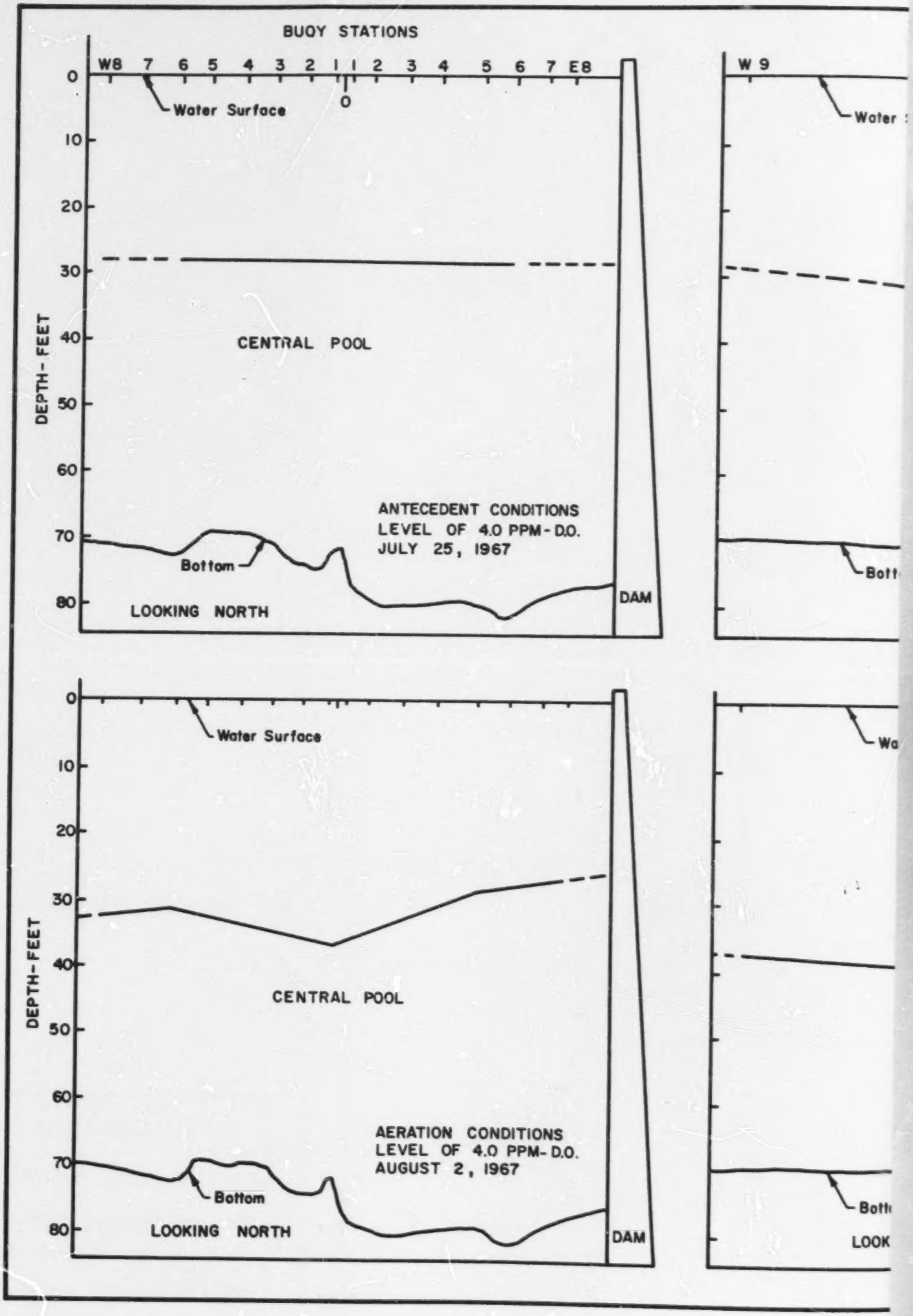
BUOY STATIONS
W8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 E8
0
Water Surface
DEPTH-FEET
10
20
30
40
CENTRAL POOL
50
60
70
80
Bottom
LOOKING NORTH
ANTECEDENT CONDITIONS
LEVEL OF 4.0 PPM-D.O.
JULY 25, 1967
DAM
W 9
Water
Bott
Water Surface
CENTRAL POOL
Bottom
LOOKING NORTH
AERATION CONDITIONS
LEVEL OF 4.0 PPM-D.O.
AUGUST 2, 1967
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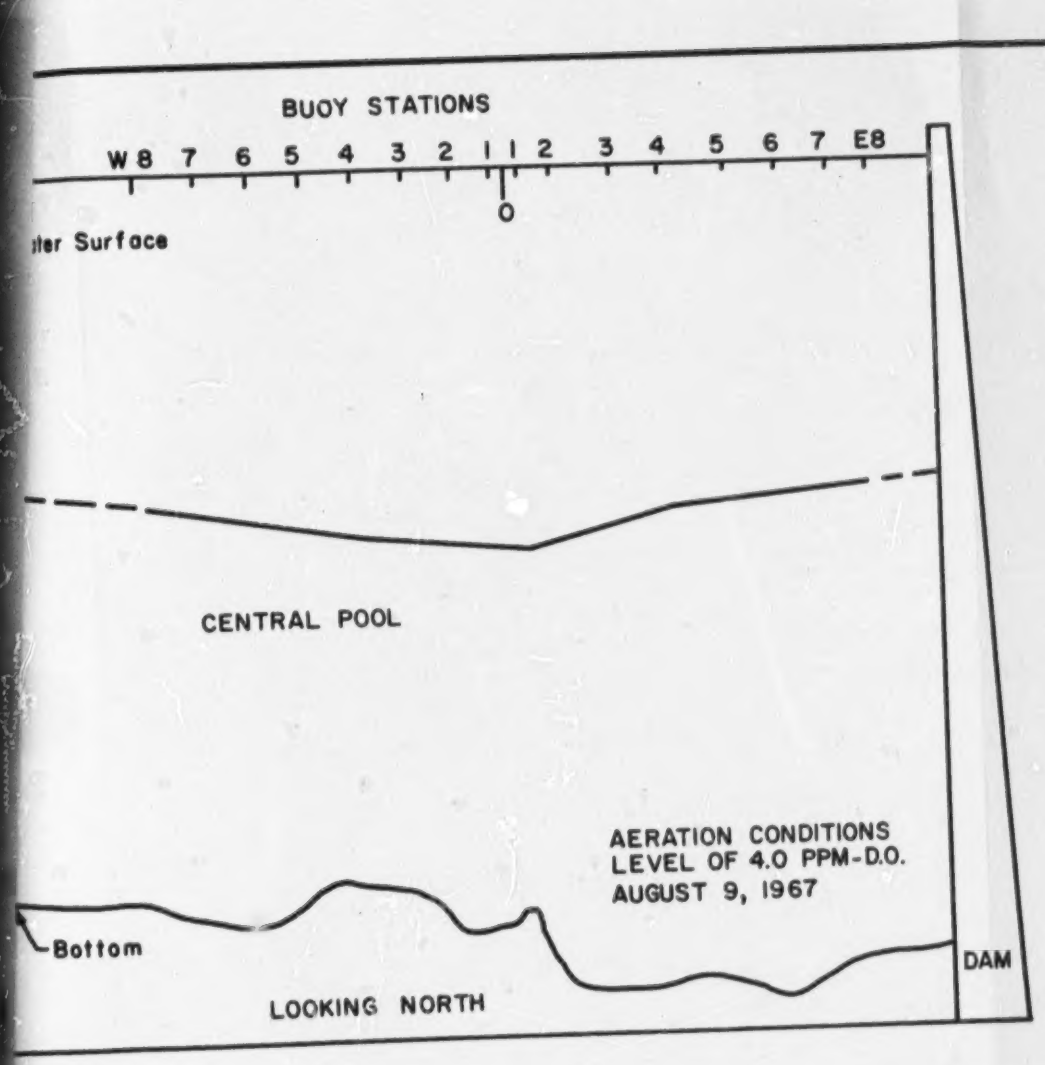

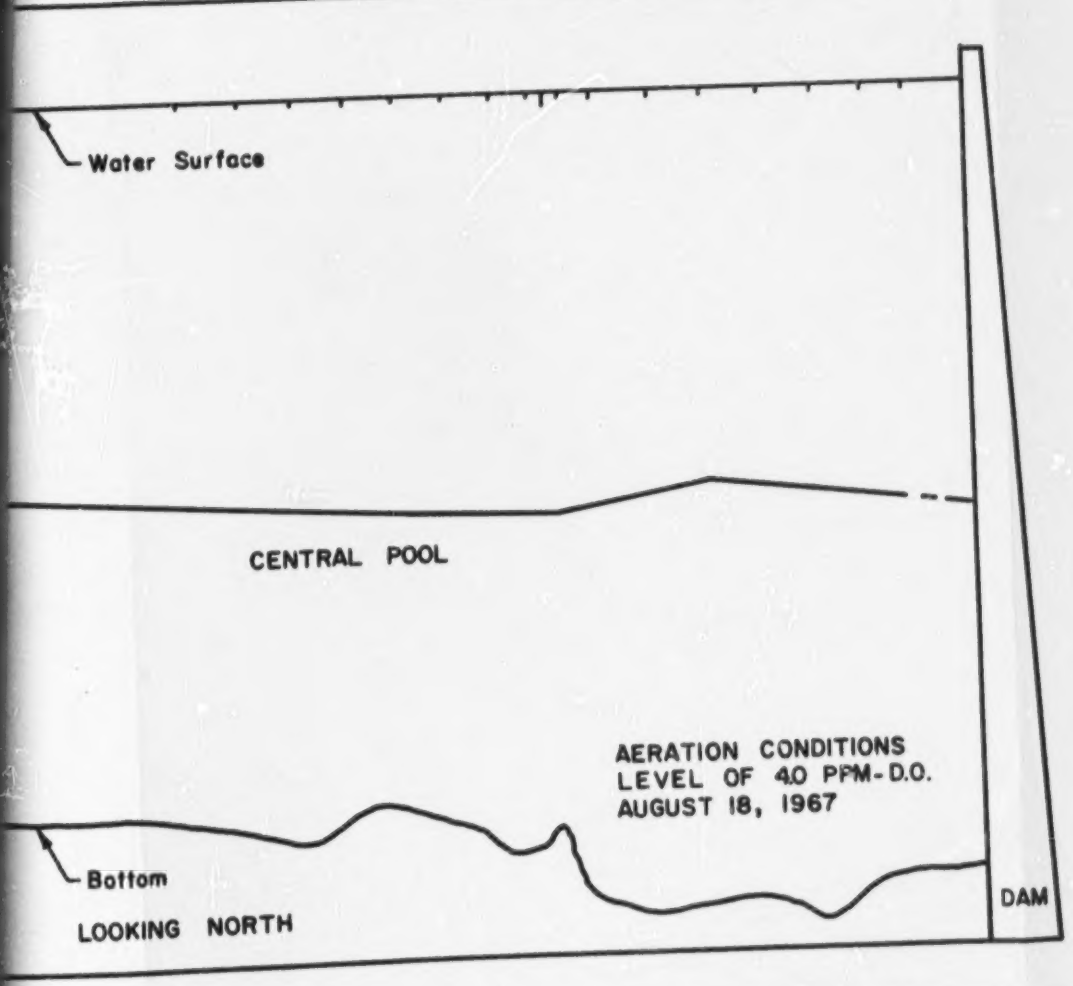

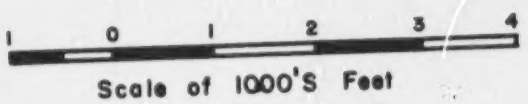

PILOT STUDY OF DYNAMICS OF RESERVOIR DESTRATIFICATION

PROGRESSIVE AERATION EFFECTS

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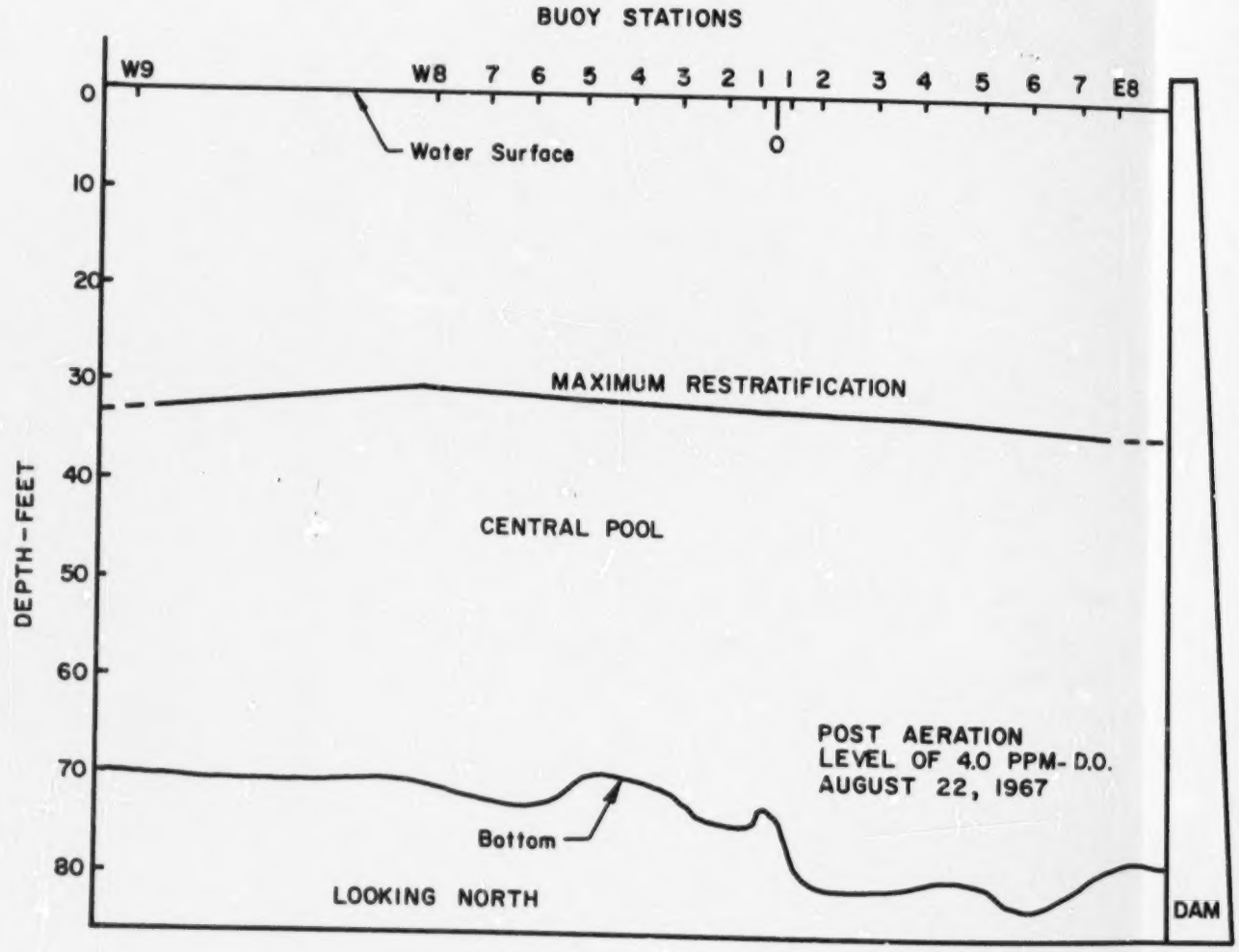
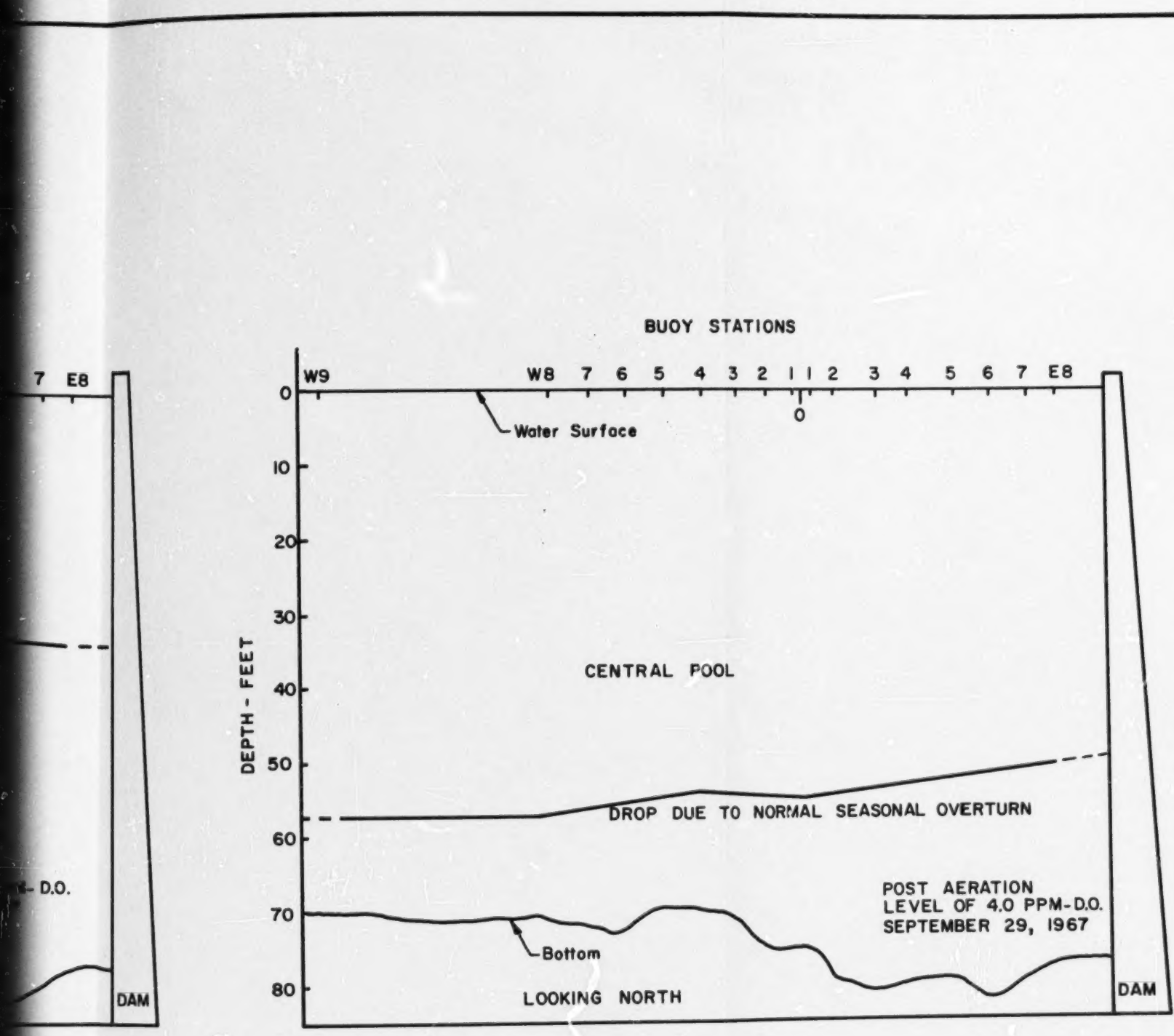
FIGURE 6

Restratification was rapid after aeration ceased on August 18, followed by normal "overturn" due to seasonal changes (Figure 7). Restratification occurred during a 4-day period immediately after aeration ceased, but the 4.0-ppm dissolved oxygen level did not completely return to its initial elevation. After restratification had reached its greatest intensity, the reservoir began to cool as a result of lower air temperatures and the dissolved oxygen levels gradually increased in depth, finally becoming completely isothermal at 20°C and having a constant dissolved oxygen level of 7.5 ppm by October 17, 1967. Isothermal reservoir conditions continued through December 1967. Water temperature decreased steadily to 11°C in mid-December, while the dissolved oxygen level throughout the central pool steadily increased to more than 10 ppm during the same period.

The volume of water affected by the system was computed based on the volume of the cone of influence below the 22-foot depth. Radiating trajectories of the 6.0-, 4.0-, and 1.0-ppm dissolved oxygen levels were plotted for each period in question and extrapolated to their effective limits. The effective limits of their trajectories were connected, thus outlining the cone of effect for each day selected. The volume on each selected date was measured to determine the progressive change in volume with continued aeration (Table 1).


BUOY STATIONS
W9
W8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 E8
0
Water Surface
0
10
20
30
MAXIMUM RESTRATIFICATION
40
CENTRAL POOL
50
DEPTH-FEET
60
70
POST AERATION
LEVEL OF 4.0 PPM- D.O.
AUGUST 22, 1967
Bottom
80
LOOKING NORTH
DAM



1 0 1 2 3 4

Scale of 1000'S Feet

PILOT STUDY OF DYNAMICS OF
RESERVOIR DESTRATIFICATION

POST AERATION EFFECTS

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FIGURE 7

14 h

Table 1. SUMMARY OF DESTRATIFICATION EFFECTS

DATE	HOURS OF COMPRESSOR OPERATION	VOLUME* OF AERATED WATER AC-FT	ACCUMULATED POUNDS AIR PUMPED	THERMAL ENERGY DIFFERENTIAL KW-HR X10^5
July 28, 1967	70	30,600	184,400	1065
Aug. 2, 1967	200	36,000	449,500	1140
Aug. 7, 1967	320	45,600	614,100	2210
Aug. 9, 1967	365	59,500	722,900	2710
Aug. 16, 1967	535	59,800	980,700	1860**
Aug. 18, 1967	580	65,800	1,109,600	2600**

* The volume of effect was considered only below a depth of 22.0 feet.

** Cooler temperature gradient than previous dates due to several consecutive days of cool, cloudy weather as well as greatly reduced air pressure and flow from the compressors.

Energy input was determined using destratification efficiency methods outlined by Symons (12, 13). Differences in stability energy units for the isolated volume of artificially aerated water were computed using control temperature conditions and temperature conditions for several separate periods of aeration. However, in several cases, the difference in computed stability values was negative or near zero. This technique considers the entire body of water utilizing temperature gradients for separate periods of time. During aeration of a large reservoir, however, only an isolated portion of the total volume may be affected and the isolated volume continues to increase as aeration progresses. Since the affected volume continually changes with resultant changes in stability, it does not appear feasible to use this technique for determining energy added to a large reservoir during aeration.

The method used for evaluation of the pilot study system takes into account compressed air input, volume of water affected, and effective thermal energy input. The weight of compressed air input in pounds based on the gauged input volume, pressure, and temperature was computed using the basic equation $pv=RT$ where: p is the absolute pressure in lbs/ft^2, v is the specific volume in ft^3/lb of air, T is the absolute temperature in degrees Rankine, and R is a constant for air (53.3 ft/degree Rankine). The accumulated weight of air pumped into the central pool was compared to volume of water affected for various periods of time during the progress of operations. This comparison is made in Table 1.

It should be noted that there was no significant change in water volume affected from August 9 to August 16. This resulted from cool weather conditions and compressed air being pumped into the reservoir at very low pressures. The low air pressures were partially due to mechanical problems with the compressors. The pilot system would have been more efficient had larger air distribution lines and less restrictive connections been used. The pressure drop from the panel board to the diffusor candles was from 65 psig to less than 1 psig with only the top half of the candle discharging air. The bubbling pressure of the candle is approximately 0.5 psig.

Thermal energy input into the central pool was computed from the difference in the mean temperature profiles at the upstream control stations and the mean temperature profiles of stations in the central pool. These values represent the difference in thermal energy of the aerated portion of the central pool and that of the same body of water on a particular date had there been no aeration. These energy values, expressed in kilowatt-hours, are differences in energy on particular dates during aeration. The mechanical energy input is accumulative; however, effective thermal energy is based on differential temperature gradients of affected and unaffected areas and is not accumulative energy. As mechanical input increases and aeration time progresses, the volume of aerated water increases. There was a sharp drop in thermal energy on August 16 when the compressors were not producing

sufficient air pressure and volume to maintain circulation in the central pool.

Further development of the thermal energy relationship versus mechanical energy input should result in a very effective means of evaluating the efficiency of this system and other systems being used for destratification. An efficiency index may serve as a future guide for spacing of systems for destratification of entire reservoirs.

An interesting observation was made by a professional scuba diver during destratification operations. The diver noticed, prior to the destratification operations, that fish were present at maximum depths of 18 to 25 feet; but when destratification was in progress, the number of fish increased in the affected area and fish were also present at maximum depths of 45 to 50 feet, the greatest concentration occurring in the immediate area of the aeration cone. These observations were made on several occasions by the diver and noted to be unusual for Eufaula Reservoir for that particular time of year.

As a result of the reported change in distribution of fish and their increased numbers, there has been a great deal of interest from fisheries biologists to study the influence of the destratification effects on fishes and other biological parameters including plankton, benthic macroinvertebrates, nutrients, and photosynthesis.

SUMMARY

The pilot study of dynamics of reservoir destratification has advanced development and design of a system to destratify large reservoirs. Rate of change of the water volume affected and the magnitude of aeration were determined in the central pool of Eufaula Reservoir. The pilot system was undersized for circulating the entire volume of the central pool, yet 65,000 acre-feet of water below a depth of 22 feet was aerated by the 25th day of operation. Aeration effects extended as far as 2.5 miles from the point where the system was installed, covering an area of approximately 3,000 acres at a depth of 22 feet. Rate of change of hydrodynamic aeration trajectories and thermal effect versus mechanical energy input are discussed. Pilot system design and operational limitations served as a guide for design of a more effective system for continued research and development of destratification of large reservoirs.

Interesting changes in vertical distribution and concentrations of fish have prompted proposals from other agencies to conduct parallel research on effects of destratification on fish populations and other biological parameters.

FUTURE WORK

The present study was based on projections of studies conducted by other researchers (1-3) who used similar systems on very small reservoirs. The results obtained from the 1967 study were extremely favorable for complete control of stratification in very large reservoirs.

Plans are being made to continue this work during the summer of 1968, with modifications of the system being made based on experience gained during the 1967 study. The type and size of equipment used, the volume of water aerated, and hydrodynamic changes in the central pool have served to guide redesigning of the system requirements for destratification of the entire central pool of Eufaula Reservoir. The type of system proposed will have one or more electrically powered rota-screw-type air compressors capable of producing 1200 cfm of free air at 125 psig. For practical application, convenience, and safety during continued study, the compressors will be located either on the dam or an accessible shore location near the dam.

The air distribution system will be completely redesigned. Larger diameter piping and a greater number of diffusor candles to reduce pressure loss in the system will be used.

The destratification operation will be a two-phase study. The first phase will be started in early June after the central pool has become intensely stratified and has stabilized. The central pool will be aerated at the maximum rate for four

consecutive weeks, stopping for three or four weeks to allow complete restratification. The system will be modified for the second phase by changing either the air distribution system or the rate of air flow. The distribution system may be modified by using a different number of the same size diffusor candles or the same number of diffusors of a different size. In addition to measurements of dissolved oxygen, temperature, and conductivity, samples will be collected at various depths on a regular basis and analyzed for chlorides, sulfates, and total dissolved solids. Buoy stations located in the upper reservoir control area will be monitored for static control through the entire project.

As a result of the behavior of fishes as noted during the present study, cooperative research will be conducted by the Oklahoma Department of Wildlife Conservation and the Oklahoma Cooperative Fishery Unit of the Bureau of Sport Fisheries and Wildlife. The project will entail evaluation of the effects of large-scale artificial aeration and destratification by use of compressed air on the distribution of fish and fish-food organisms in a stratified reservoir. Effects of the influence of aeration and destratification on nutrient distribution and primary productivity will also be determined.

The U. S. Fish and Wildlife Service will also conduct a study to determine both daytime and nighttime distribution of fish by using echo sounding equipment and a midwater trawl.

Measurements will be made during destratification in the aerated portion of the central pool and in a relatively undisturbed control area for approximately four days.

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